Influence of Sheds Inclination of Non-Ceramic Insulators on Develop of Leakage Current in the Rain and Fog Conditions

W. Bretuj, K.Wieczorek
Institute of Electrical Engineering Fundamentals of the Wroclaw University of Technology
Wybrzeże Wyspiańskiego 27
50-370 Wroclaw, Poland

Abstract- **The paper presents results of laboratory tests of HTV silicon rubber insulators with different inclination of upper surface of the sheds (10º, 30º) in the rain and fog chamber. The main stresses were AC (50 Hz) high voltage in presents of periodical rain or fog. During the tests leakage current was recorded. After the tests surface hydrophobicity was evaluated. The goal of test of silicone rubber insulators in fog and rain chambers is to obtain of experimental dates which show influence of their sheds inclination on develop of leakage current in rain and fog conditions.**

I. Introduction

Silicone rubber insulators offer a lot of advantages over ceramic such as light-weight construction, ease of installation and maintenance, vandalism resistance, improved contamination performance due to use hydrophobic materials and compact line design. The most valuable feature of these insulators is hydrophobic property [1,2]. This property is responsible for the low wettability that reduces develops of leakage current and surface discharges and makes it necessary to minimize the effect of their relatively low ageing resistance. Additional in presents of pollution silicone rubber allow transferring of low molecular fraction (LMW) from the bulk to its surface.

As regards ceramic insulators, researchers have paid much attention to shape optimisation and the gained experience is now applied in the design of composite insulators. But the transfer of experience relating to the shape of ceramic insulators directly onto composite insulators does not allow one to fully exploit the advantages of polymer materials, especially their low surface energy.

Present of water in the form of rain or fog causes silicon rubber insulators to nonuniformly lose their hydrophobic properties as a result of the washing out of low molecular fractions from the surface of the silicon rubber [3] and corona discharges from water droplets [3,4]. The consequence of the nonuniform loss of hydrophobic properties by insulator surfaces and the formation of intershed water bridges [5,6] are highly nonuniform distributions of voltage and electric field intensity. They may cause the initiation and development of surface discharges having a highly corrosive effect on the silicon housing materials [7], which may lead to serious damage to the insulators.

The shape of the composite insulator and the design parameters of its sheds play a significant role in this mechanism of ageing which on the whole is similar in rain and fog conditions.

II. Subject of Investigation and Tests Setup

Model composite insulators with their housings made of silicon rubber, destined for 24 kV rated voltage were investigated. The insulators had a very similar dry arcing distance (275-295 mm) and a leakage current distance (645-660 mm), as required by the basic criteria classifying composite insulators from the electrical point of view, specified in IEC 61466-2. They differ in their inclination of upper surface of the sheds. The same housing material – high-temperature vulcanised silicone rubber (HTV) – was used to manufacture the model insulators. Figure 1 shows a picture of tested insulators.

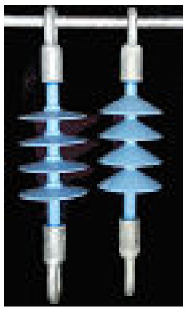


Figure 1. The tests subjects – 4 sheds HTV insulators.

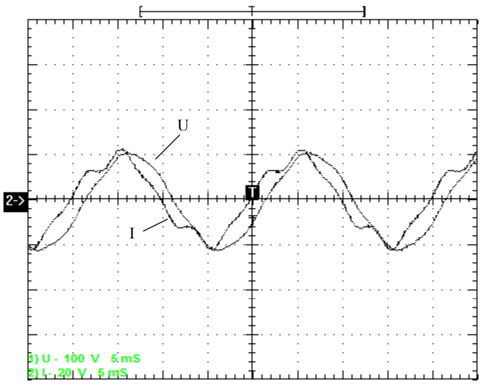
The tests were carried out in high voltage fog and rain chambers. The fog chamber was equipped with a standardized system of nozzles located in opposite corners. The fog generating unit includes an oil compressor and a water pump. The system operates in a closed cycle and is controlled by a time programmer. The sprinkling system operates in a similar way. The water's conductivity was 200 mS/cm.

The test plan provided for 7 hours of ageing with each hour comprising a 30 minute (fog or rain) sprinkling cycle and a 30 minute period with no fog or rain generation. After ageing the insulators 'rested' for 17 hours. The insulators were aged at a voltage of 40 kV.

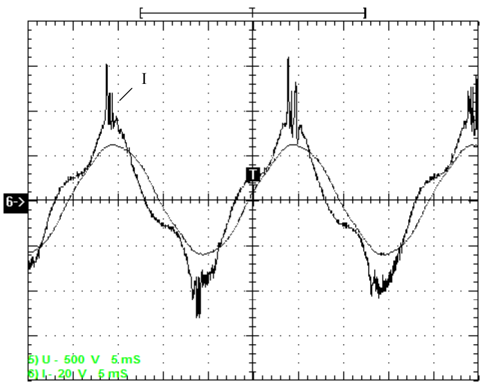
To the leakage current registration was used a PC computer and a METEX multimeter. The rain chamber was equipped in different sprinklers, the system was without a compressor and a programmer controlled only the pumps. The water's conductivitiy in tests in the rain chamber was on the same level as in case the fog chamber.

III. Test Results

The most important parameter was recorded leakage current which also indicate indirectly level of surface hydrophobicity. Gradually loss of hydrophobic properties caused increase of leakage current level. Comparison of recorded current shapes allows pointing at the better insulator sheds inclination. Problem of silicone rubber insulator shape optimization was presented in [8].



a)

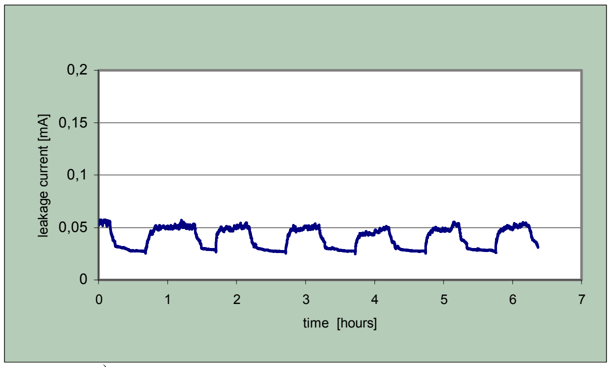


b)

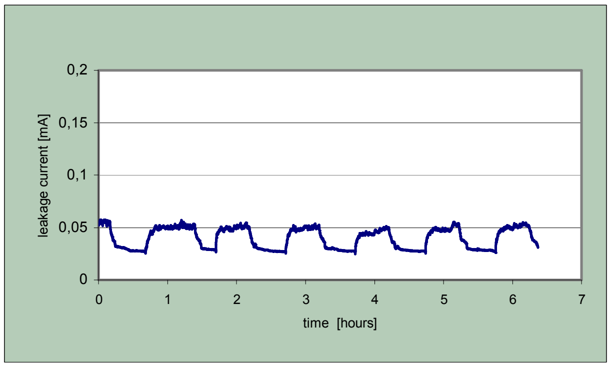
Figure 2. Leakage current oscillograms registered after 24 days of ageing in the rain chamber,

a) insulator with sheds inclined at 30°,
b) insulator with sheds inclined at 10°.

Figure 2 shows oscillograms made after 24 days of ageing in the rain chamber. In the case of the insulator with a shed inclination of 30° the leakage current has still a capacitive character (Fig. 2a) whereas in case of the insulator with a shed inclination of 10° current has a resistance character (Fig. 2b). The leakage current is clearly higher for the insulator with its sheds inclined at an angle of 10°. The discharges, having the form of blue threads, develop on the undersides of the sheds, especially on the underside of the first shed on the high voltage side.



a)



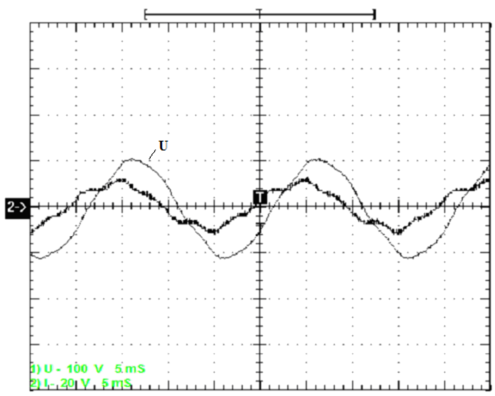
b)

Figure 3 Leakage current versus aging time on 28th day of ageing in the rain chamber,

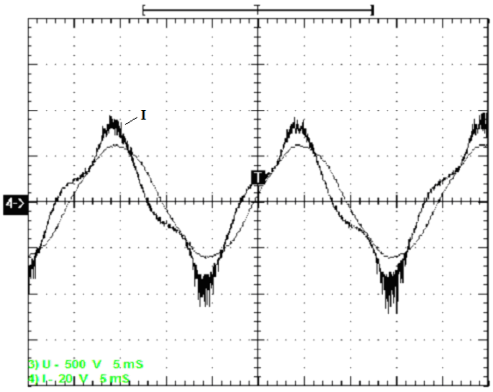
a) insulator with sheds inclined at 30°,
b) insulator with sheds inclined at 10°.

Figure 3 shows diagrams of leakage current versus aging time. The highest value of current was registered for insulator with a shed inclination of 10° and was exceed 0,15 mA whereas for 30° insulator was on the level 0,05 mA.

Figure 4 presents oscillograms made after 25 days of ageing in the fag chamber.



a)

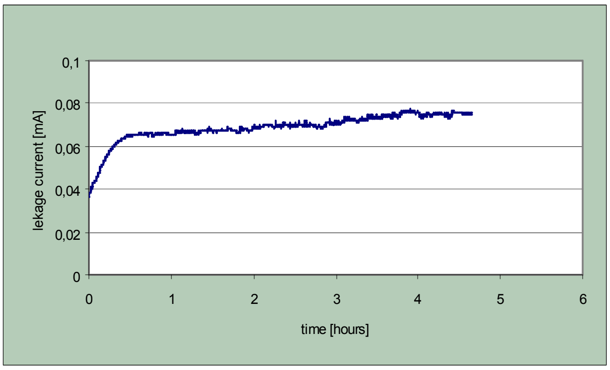


b)

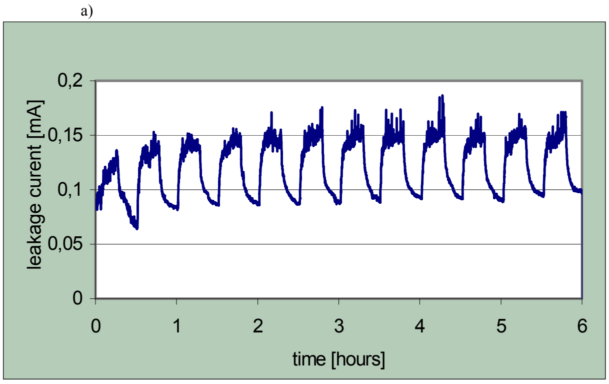
Figure 4. Leakage current oscillograms registered after 25 days of ageing in the fog chamber:

a) insulator with sheds inclined at 30°,
b) insulator with sheds inclined at 10°.

The results are similar to results obtained in the rain chamber. In the case of the insulator with a shed inclination of 10° shape of current curve indicate on surface discharges occurrence. Current amplitude is also much higher than in case of insulator with a shed inclination of 30°.



a)



b)

Figure 5 . Leakage current versus aging time on 28th day of ageing in the fog chamber:,

a) insulator with sheds inclined at 30°,
b) insulator with sheds inclined at 10°.

Leakage currents recorded in the fog chamber are showed on Figure 5. In this case insulator with a shed inclination of 30° turned out again better than insulator with a smaller inclination of the sheds. The highest value of leakage current did not exceed 0,08 mA and shape of the current curve was almost flat (Fig. 5a) whereas for the insulator with almost flat sheds this value was equal 0,18 mA.

IV. CONCLUSIONS

Angle of sheds inclination is important construction parameter of high voltage silicone rubber insulator. Steep inclination upper surface of insulator sheds reduce process of losing hydrophobicity and develop of leakage currents which leads to surface discharges in rain and fog conditions. Thus in outdoor application of insulators with steep sheds inclination can have better aging resistance.

REFERENCES

[1] S. H. Kim,E. A. Cherney, R. Hackam, “Hydrophobic Behaviour of Insulators Coated with RTV Silicone Rubber”, *IEEE Trans. on Electrical Insulation*, vol.27, June 1992, pp. 610-622.
[2] R. S. Gorur, “Hydrophobicity”, *INMR*, July/August, 1999, pp. 64-68.
[3] H. Hillborg, U. W. Gedde, "Hydrophobicity changes in silicone rubbers", *IEEE Transactions on Dielectrics and Electrical Insulation*, Vol. 6, No. 5, 1999, pp. 703-717.
[4] A. J. Philips, D. Childs, H M.. Schneider, "Water drop corona effects on full scale 500 kV non-ceramic outdoor insulators", *IEEE Transactions on Power Delivery,* Vol. 14, 1999, pp. 258-265.
[5] A. De La O, R. S. Gorur, "Flashover of contaminated non-ceramic outdoor insulators in a wet atmosphere", *IEEE Transactions on Dielectrics and Electrical Insulation*, Vol. 5, No. 6, 1998, pp. 814-823..
[6] J. Fleszyński, E. Sojda, P. Żyłka, "Flashover peformance of artificially contaminated silicone rubber composite insulators", International Conference on Advances in Processing, Testing and Application of Dielectric Materials, Wrocław, Poland, September, 17-19, 2001, pp. 100-103
[7] J. Fleszyński, M. Lisowski, M. Adamowska, Z. Świerzyna, "Resistance to tracking and erosion of silicone elastomers used in composite insulators", International Conference on Advances in Processing, Testing and Application of Dielectric Materials, Wrocław, Poland, September, 17-19, 2001, pp. 225-228
[8] El-Hag A. H., Jayaram S. H., Cherney E. A., Influence of shed parameters on the aging performance of silicone rubber insulators in salt-fog, *IEEE Transactions on Dielectrics and Electrical Insulation*, Vol. 10, No. 4, 2003, pp. 655-664